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Major David B. Moore

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Marine Corps University
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Austere expeditionary habits cease in many cases when Marine forces become a "second land army" aboard large Forward Operating Bases (FOBs) in Afghanistan. There, excessive energy usage due to inefficient equipment and wasteful energy habits results in long, tenuous supply lines through miles of neighboring Pakistan. The convoys carrying these supplies are at constant risk of attack. Payments made to local warlords for convoy protection often end up in the hands of Taliban fighters, fueling their efforts and damaging COIN strategy. These bloodlines support a finite number of troops at current FOB consumption levels. As troop levels increase in theater, resupply challenges increase and commanders may experience limited operational flexibility due to logistics strains. The solution involves a combination of the following: knowledge and leadership; elimination of key, non-essential excesses; remedies to current power generation and distribution configuration problems; appropriate monitoring and enforcement of electricity demands on FOBs; and technological upgrades to shelters and power generation on FOBs and Combat Outposts (COPs).

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MASTER OF MILITARY STUDIES

LEAN, MEAN, AND GREEN: AN EXPEDITIONARY IMPERATIVE

SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF MILITARY STUDIES

MAJOR DAVID B. MOORE, USMC

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Mentor and Oral Defense Committee Member: ~~Dr.~~ Adam Cobb

Approved: _____

Date: 4/29/2010

Oral Defense Committee Member: David F. Bittner, PhD

Approved: _____, Professor of History

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Executive Summary

Title: Lean, Mean, and Green: An Expeditionary Imperative

Author: Major David B. Moore, USMC

Thesis: The waste of non-renewable resources by U.S. forces on Forward Operating Bases renders these forces less expeditionary, more vulnerable, and hinders their ability to achieve strategic success in the counterinsurgency (COIN) mission.

Discussion: Fast, austere, lethal—this is how the USMC Commandant, General James T. Conway, describes an expeditionary force. However, austere expeditionary habits cease in many cases when Marine forces become a "second land army" aboard large Forward Operating Bases (FOBs) in Afghanistan. There, excessive energy usage results in long, tenuous supply lines through many miles of neighboring Pakistan in an effort to support the war effort. The convoys carrying these supplies are at constant risk of attack, threatening to offset a dangerous balance between supply and demand. Inefficient equipment and wasteful energy habits aboard these FOBs demand expensive fuel, the purchase of which often profit terrorist-funding, unstable governments. Additionally, payments made to local warlords for the protection of these convoys often end up in the hands of Taliban fighters, fueling their efforts and damaging our COIN strategy. The dangerous problem is that these bloodlines will support only a finite number of troops at current FOB consumption levels. As troop levels are set to increase by 30,000 in the coming year, room for error in the resupply effort vanishes and commanders may experience supply, fuel, and logistics strains that begin limiting operational flexibility.

The solution involves a combination of the following: knowledge and leadership up and down the chain of command of the benefits conservation and efficiency bring to operational flexibility; identification and elimination of key, non-essential excesses that draw the highest power demands; a remedy to current power generation and distribution configuration problems; an appropriate level of monitoring, oversight, and enforcement of electricity demand limitations on FOBs; and technological upgrades to shelters and power generation with the goal of net-zero FOBs and Combat Outposts (COPs).

Conclusion: In order to preempt the operational limitations imposed by excessive demand for fuel to support troops living on FOBs, it is necessary to take immediate action in reducing power demands and upgrading to efficient power generation, thus preparing for current and future troop increases. Additionally, the excessive logistics tail that fuels the current living conditions also fuels and funds the enemy's strategy and degrades the effectiveness of U.S. COIN efforts.

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Preface

Like many who have become interested in the need to improve expeditionary efficiency, I was first drawn to the issue after hearing that a gallon of fuel in Afghanistan costs our forces $400 by the time it reaches the end user. The monetary cost, while extraordinary, was not altogether surprising, having seen firsthand the long convoys into Iraq and the extreme efforts that go into maintaining our technological advantages in combat. My chief concern, however, was if the money would dry up, and whether this cost had begun to manifest itself in the prosecution of the war. That led me to wonder if there was also a physical limit of supplies that could reach our forces, into and through Afghanistan. As I began researching, another issue surfaced, and that was the proliferation of disinformation surrounding the issue. Misunderstood facts became sources that were quoted by other sources, and the issue became skewed. Our expeditionary forces need expeditionary, renewable sources of energy so as to be less dependent on a continuous logistics tail and host nation support. In turn, the logistics "tail" becomes shorter and less vulnerable to being severed by the enemy. Inflated costs and casualty figures associated with supply methods may bring industry to the problem-solving table, but the need for a solution is easily countered if that need is based on misinformation. Thus, as a side effort to defining the problem and offering solutions, I will bring the truth to the issue in this paper in an effort to reestablish solid understanding and unity of effort.

The scope of this endeavor deserves defining, as a complete solution to the problem would involve a broad spectrum of short-, mid-, and long-term solutions. The issues lending to such a continuous, growing demand for supplies point to, at a minimum, the need for upgrades in both power and water production. However, as a suitable water solution appears to be close at

hand, I chose to deal specifically with the current excesses in fuel demand for power production. Additionally, I do not address fuel used directly in action against the enemy, as in aviation and ground vehicles. Efficiency solutions in those areas could yield substantial results, however, those solutions fall more into long-term acquisitions efforts. Thus, the scope is limited to issues surrounding fuel for use in supporting life on FOBs and COPs.

An explanation of some terminology will enhance understanding of this paper. "Operational flexibility" is used several times throughout this text, and it refers in this paper to a commander's capacity to conduct operations unrestrained by resource limitations. The term "efficiency" is in reference to equipment in terms of its ability to produce the desired result with minimal fuel or waste. Finally, "conservation" refers to human behavior and practices that minimize waste of resources.

Several individuals deserve acknowledgement for their contributions to this study, without which I would have likely followed the highly tread path of disinformation. I would like to thank in particular Dr. Adam Cobb for his mentorship throughout this process, and the Marine Corps University Foundation, for making my attendance possible to the USMC Expeditionary Power and Energy Symposium in New Orleans, LA. I would be remiss if I did not acknowledge the patience and support of my wife, Samantha, who also contributed much of her time to the multiple revisions throughout the year. Additionally, the following individuals provided assistance in research, access to information, or revision assistance and expertise.

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Major Patrick Reynolds, Project Officer for the ExFOB
Major Keith Kopets, USMC Commandant speechwriter
Major Brian Grana, USMC Command and Staff student
Major Brian Ashford, USMC Command and Staff student

Major Isaac Lee, USMC Command and Staff student
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Kathleen Gallaher, Gray Research Center
Andrea Hamlen, Gray Research Center

I. Introduction

> *In transporting provisions for a distance of one thousand li[1], twenty bushels will be consumed in delivering one to the army...If difficult terrain must be crossed even more is required.*[2] *Sun Tzu*

Historically, Marines have been masters at the rapid buildup of combat power and the conduct of combat operations, followed by a turnover with occupational forces and subsequent withdrawal.[3] To conduct the full range of missions "in any clime and place" requires an inherent ability to adapt to austere environments while focusing unhindered on the mission at hand. This is the nature of an expeditionary force, and the business of Marines. As the Marine mission in current contingencies evolved to include occupation and subsequent combat operations from forward operating bases (FOBs), expeditionary thinking grew stagnant. The change in mission posture brought with it a change in mindset. Marines have learned to settle in and make themselves as comfortable in a FOB "garrison" as they are at home in the U.S. As creature comforts of home find their way into these growing FOBs, logisticians scramble to fuel the infrastructure via a treacherous convoy supply line. These convoys trek long distances through neighboring countries such as Pakistan, and include both contracted and military security forces and vehicles, air support, and logistical support. The effort pulls assets that could be available for offensive operations against the enemy, but are instead used to ensure the safe, continuous arrival of fuel to the FOBs. It presents the enemy with an endless line of targets and thus a foolproof strategy, as well as a continuous source of funding to fuel his cause.

While much of the fuel arriving to FOBs is used for direct combat and combat support purposes, a large percentage goes directly into supporting and sustaining the FOB itself. A 2008 Army study by the Defense Science Board (DSB) showed that generators had the highest consumption of fuel when compared with combat vehicles, combat aircraft, tactical vehicles, and

non-tactical vehicles in combat theaters.[4] However, aging generators and electric grids that currently power FOBs have been in use for over three decades, which may partially account for the inefficiency with power production in FOBs.[5]

Beyond the FOBs, fuel and supplies are transported to even more remote areas—Marines living and fighting at the tactical edge in the Combat Outposts (COPs). The threat level to this tenuous but vital supply artery increases as convoys move supplies further inland.[6] Fortunately, the end user in this case is a battalion-, company-, or platoon-sized COP and thus a lower fuel demand. One obvious reason for this is that there are fewer Marines to support at these outposts. The primary reason is the lack of the heavy fuel-consuming, comfort devices enjoyed at the larger FOBs, as well as the harder living conditions endured by these Marines.[7]

Lack of both efficiency and conservation is a central issue.[8] For example, deployed tents and structures, many of which are unoccupied, are being pumped with air conditioning or heating with little or no ability to insulate the facilities.[9] Chow halls crank out meals around the clock, creating fuel demands that exceed combat uses of fuel in some cases.[10] As long as the fuel continues to arrive, the generators are run with little regard for the implications. Commanders are focused on the offensive mission at hand and the safety and well-being of their troops. Commanders' rightful focus on the mission and enemy leave them largely unaware of the origin of fuel; the means by which it arrives; and, in most cases, the cost in dollars, lives, and equipment of getting it to its destination. Similarly, a focus on conservation is of little interest to the warfighting commanders, other than perhaps to avoid the hecklings from logisticians. They often fail to see the link between conservation and operational flexibility against the enemy. At the operational level, conservation translates into reduced vulnerability on the roads, more fuel to be reallocated toward combat operations, more available troops and escort aircraft for combat

missions as opposed to convoy security, and better political support for the war due to the greater success in counterinsurgency (COIN). More importantly, it translates into the ability to support more forces in theater as the situation warrants. Alternately, lack of conservation and continued use of inefficient equipment precludes the sustainment of larger force numbers, thereby imposing a limit on a theater commander's ability to wage war.

The potential real danger lies in the fact that there may be a physical or monetary troop supportability limitation tied directly to the problem—how many more troops can be supported? The answer to this question directly affects operational combat power in theater, which could hinder strategic success. Thus, the waste of non-renewable resources by U.S. forces on Forward Operating Bases renders these forces less expeditionary, more vulnerable, and hinders their ability to achieve strategic success in the COIN mission.

This study will begin by summarizing a historic parallel to help illustrate the problem and its potential consequences. Then the study will introduce specifics of the problem and its operational and strategic implications. Finally, potential solutions will be explored through the lens of conservation and technological innovations. The goals of this paper are three-fold. The first goal is for tactical and operational commanders to appreciate the relationship between conservation and technological innovation that result in increased operational flexibility while partially nullifying the enemy's strategy. At the strategic level, commanders will see the implications of improving efficiency and conservation in terms of supportability for an increased troop capacity that translates into improved flexibility. Second, the acquisitions field must modernize equipment in order to have the greatest impact on true, long-term expeditionary energy efficiency. The last goal is to demonstrate that developing energy-efficient systems and mindsets are akin to fielding a new, lethal weapons system.

II. Soviet/Afghan War Case Study

American forces can gain perspective on this issue, and perhaps realize potential implications, by looking at the Soviet Army's recent, failed campaign in Afghanistan. The Soviet 40th Army invaded Afghanistan in December 1979 after watching a deteriorating situation worsen when a series of coup d'états left an unstable Communist government in power in the nation's capital, Kabul.[11] The Soviets intended to swiftly install a new pro-Moscow government followed by garrison duty, rather than entering into a counter-guerilla war.[12] Instead, the Soviets became involved in a non-conventional struggle against popular Mujahideen insurgents.

The Mujahideen controlled rural areas and roads between government centers as the insurgency grew, thereby cutting off resupply and leaving government posts threatened. The Soviets quickly found their military spread thin and overtaxed in the effort to provide security to the populace while building governance and training Afghan forces across a massive landscape.[13] It was not just for political reasons that the Soviets did not send enough forces into Afghanistan. The road networks through some of the most difficult terrain in the world supported a very limited throughput of supplies and fuel. The result was the ability to support the equivalent of only five and two-thirds Soviet combat divisions, to include supporting units. This had the Soviets at a peak strength of 120,000 troops in 1986.[14]

To make up for the deficient numbers, the Soviets routinely mobilized Soviet and Afghan forces from their assigned locations across the country to augment local forces and conduct large operations. Once the operation was complete, the mobilized forces returned to their bases.[15] The unfortunate consequence of this method was that in most cases, holding the objective was not an option. One example was Operation Magistral, which attempted to relieve a siege[16] on Khost that had prevented ground resupply of some 40,000 civilians and 8,000 soldiers held there since

very early in the war.[17] Resupplying Khost by air also became difficult due to hostile anti-aircraft fire.[18] Therefore, the ultimate aim of Magistral was to bring security to Khost and permanently connect that city by road through Gardez to the capital in Kabul.[19]

Operation Magistral began on November 28, 1987. Soviet tactical actions included a skillful multi-axis attack to clear enemy forces from the critical Satakandow Pass, thereby enabling Soviet/Afghan forces to reach Khost and allowing critical ground resupply of the city in just over 30 days.[20] However, additional Mujahideen commanders began arriving from Pakistan and other parts of Afghanistan to coordinate counteroffensives immediately following the defeat.[21] Similar to previous Soviet/Afghan operational successes, the superiority of forces was only temporary. The relief of Khost brought an impermanent supply relief—Soviet forces were able to keep the road open for 12 days and then withdrew due to mounting enemy pressure.[22]

Operation Magistral is just one of many examples of Soviet inability to hold objectives in Afghanistan due to insufficient forces. While the war in Afghanistan forced the Soviets to make a significant change in their counterinsurgency tactics and force structure, the Soviet Army never had enough forces in theater to win, and the forces that were in theater were chronically under-resourced.[23] U.S. forces are already challenged in maintaining a steady rate of fuel and supplies given current energy consumption rates.[24] As forces in Afghanistan increase by 30,000 this year, closing in on the Soviet force levels, American forces may begin to experience similar limitations to operational flexibility.

III. The Problem

> *Fuel that is transported at great risk, great cost in lives and money, and substantial diversion of combat assets for convoy protection, is burned in generator sets to produce electricity that is, in turn, used to air condition un-insulated and even unoccupied tents.*[25]

The Fully Burdened Cost of Fuel (FBCF).[26]

In order to fully appreciate the energy problem, it is necessary to understand FBCF first. Simply stated, the FBCF is the true cost of fuel once it is delivered to battlespace forces after applying all the costs of getting it there.[27] This concept brings up the majority of reasons given for why U.S. forces need immediate fuel efficiency improvement. There is the view that every gallon of fuel in Afghanistan costs $400.[28] Another view is that $400 per gallon fuel is inaccurate and arbitrary, and that fuel could never cost that much. Perhaps there are those that believe that the FBCF is the cost of doing business at war, and the cost is irrelevant. It is important to first bring out the truth in order to properly solve the problem.

The DoD purchases fuel for deployed use from the Defense Energy Support Center (DESC). The DESC maintains a global network of supply points for all types of DoD fuels, and maintains contracts with local refineries.[29] The DESC price for fuel is the beginning point for the FBCF. Included in the DESC price are any transport and intermediate storage costs incurred prior to the military supply point.[30] Any additional costs incurred on the way to the FOB or COP make up the rest of the FBCF. Included within the FBCF would be costs incurred by delivery platforms, protection assets, and refueling assets and fuel requirements of delivery platforms.[31]

In Afghanistan, the FBCF also includes fees paid to Afghan trucking companies and security firms to provide protection services. Protection is provided through payments to local warlords who essentially pay Taliban not to attack their convoy as they transit through high risk territory. These payments can be as high as $800-$1500 per truck, depending on the type of truck and the cargo being transported, with fuel trucks, High Mobility Multi-purpose Wheeled Vehicles (HMMWVs), and Mine Resistant Ambush Protected vehicles (MRAPs) on the high end of this cost range. Compounding the situation, Afghan security firms recently increased their

charges with news of the coming surge of coalition troops. Military officials estimate that 10 percent of logistics contracts consist of payments to insurgents, equivalent to hundreds of millions of dollars.[32] The situation could turn perilous if the Taliban decided to stop accepting security payments and instead increased the attacks on the convoys.

The DoD currently has not established official values (i.e., dollar amounts) to use for the FBCF.[33] Nevertheless, efforts have been made to quantify the factors that go into the FBCF. Current estimates of delivery costs range from $4 per gallon for ships on the open ocean, to $42 per gallon for in-flight refueling, to several hundred dollars per gallon for combat forces and FOBs deep within a battlespace.[34] The oft quoted figure of $400 per gallon is for the latter.[35] This $400 figure, identified in the 2001 Defense Science Board (DSB) Report, "More Capable Warfighting Through Reduced Fuel Burden," represents a worst case scenario where fuel is delivered via airborne platform at a distance of 600km (373 miles), and requires multiple, pre-staged, airborne delivered refueling points.[36] On the other hand, ground delivered fuel under the same scenario was estimated to be $30 per gallon.[37] Comparison of any of these figures with the DESC standard price of $3.04 per gallon on December 19, 2007 illustrates that the burdened costs beyond the DESC price can be enormous.[38]

Headquarters Marine Corps Programs and Resources (P & R) Program Assessment and Evaluation (PA & E) Division conducted a study in December 2009, to calculate values for the FBCF for convoy delivered fuel with and without airborne escort, as well as air delivered fuel to a COP at a distance of 35 miles[39] from the retail point of sale.[40] The inputs to the FBCF are the price per gallon of fuel paid to the DESC source, Operating and Support (O&S) costs of fuel delivery assets, depreciation costs of delivery vehicles, any fuel infrastructure costs, any environmental costs, and other costs (i.e., force protection, regulatory compliance, miscellaneous

costs). The study concluded that the FBCF for convoy delivered fuel without airborne escort was $9.20-11.81 per gallon.[41] These figures are consistent with the estimate from the 2001 DSB report when considering the large difference in distance traveled between the two calculations. The same convoy *with* airborne escort became $15.63-18.59 per gallon.[42] Airborne delivery by CH-53E with escorts was $28.94-30.78 per gallon.[43] These calculations take into account opportunity costs such as daily pay values for Marines involved in ground convoys. It may be argued that the pay should not be considered in this calculation, as these Marines would receive the same payment whether involved in the convoy or not. Instead, the pay could be considered an opportunity cost because it represents manpower devoted to that effort as opposed to other combat operations. Additionally, lost equipment or personnel due to combat or non-combat loss is not factored in, nor are any environmental costs.

FBCF Scenarios

In the scenario discussed above, the DSB concluded that aviation delivered fuel cost $400 per gallon. If Marines were conducting expeditionary amphibious operations deep inland to the same 600 kilometers distance as the DSB scenario, and a Marine Expeditionary Unit (MEU) was tasked with fuel delivery to the COP, the fully burdened cost of that fuel calculates to $364.75 per gallon, very close to the $400 per gallon DSB figure. This calculation is based on a flight of two AH-1W escorting four CH-53Es that deliver fuel via airborne CH-53E Tactical Bulk Fuel Delivery System (TBFDS). The round trip was calculated to take approximately eight hours to deliver just less than 1200 gallons of fuel to the COP, accounting for all refueling and offload operations enroute.[44] See Table 1 for the detailed calculations.

Notwithstanding the enormity of the cost, that is not the most pressing issue in this hypothetical scenario. A MEU has only four AH-1Ws and four CH-53Es assigned. That

number of aircraft constitutes one complete fuel delivery package, and each package can make only one round trip per 24-hour period, given Navy flight deck limitations of 12 hours at flight quarters per 24-hour period. The result is only 1200 gallons of fuel delivered to the COP per day. This amount can fuel six LAV-25s, eight armored HMMWVs, and six MRAPs that only transit 120 miles per day, supported by 2xAH-1Ws for two hours flying time.[45] If the fuel delivery flights encountered bad weather, aircraft problems, or Navy amphibious platform issues precluding flight conditions, then daily fuel requirements would not be met. The loss of a single days' fuel would have direct effects on the Marines' already limited operational capabilities in this expeditionary scenario. A MEU may be presented with such a scenario as this while phasing ashore, awaiting ground logistics convoys to link up and continue to build up a FOB or COP. Such was the case when the 13th MEU joined Task Force (TF) Mountain in Bagram, Afghanistan to conduct Operation ANACONDA in March 2002.[46]

During that buildup, flights of CH-53Es and AH-1Ws transited nearly 700 miles inland from amphibious shipping. The AH-1Ws refueled enroute to Bagram by both the CH-53E TBFDS as well as previously coordinated intermediate support bases (ISBs) in Pakistan.[47] Daily operations during ANACONDA were conducted from a Forward Arming and Refueling Point (FARP) that relied on CH-53 or CH-47 delivered fuel from TBFDS. These platforms filled their TBFDS tanks daily in Bagram. The Bagram fuel was delivered via C-17 or KC-130, as planners had realized early on that the bulk of supplies would have to come via airborne assets since the ground Lines of Communication (LOC) were not secure.[48] This example does not exactly mirror the scenario that resulted in the nearly $400 per gallon estimate above, but it does serve as an example in which expeditionary forces have conducted operations using fuel at fully burdened costs approaching that figure.

In this example, TF Mountain was given sufficient support allowing it to sustain forces primarily via airborne delivery. It is doubtful that small units of Marines would purposely be placed into a situation where they would be dependent on fuel to conduct daily operations against the enemy and had only one option, such as helicopter lift, for delivery. More likely, this scenario represents an emergency situation where ground resupply routes are cut off by enemy forces, such as the Soviet-Afghan example above where Khost and its outlying COPs became dependent on air-delivered fuel only.

The scenarios discussed above are important to consider for two reasons. First, it is realistic that Marines conducting expeditionary operations might require fuel at fully burdened costs nearing or exceeding $400 per gallon. Second, the methods of delivery might limit the amount of fuel that can be supplied to expeditionary forces, thereby limiting operational flexibility. The next section discusses the ground convoys that deliver fuel to allied forces in Afghanistan in order to appreciate similar challenges at the strategic level. While U.S. forces in Afghanistan are not currently paying $400 per gallon of fuel, the issue is the same as in the scenarios described above. That is, security of the continuous supply of fuel to forces deeply imbedded within the country is of utmost importance to winning the war in Afghanistan.

The Convoys

> *The supply lines into Afghanistan are an operational vulnerability that we hold, [and] at the tactical level, our enemy knows that.*[49] *USMC Commandant, General Conway*

Indeed, the ability to wage war is directly dependent on the supply arteries, and the terrain in Afghanistan has challenged invaders for centuries in this regard. Supplies are delivered to forward deployed bases in Afghanistan by two main routes – one from the Central Asian states to the north and the other through neighboring Pakistan to the east.[50] See Figure 1, NATO Supply Routes, for an illustration of these supply routes. Seventy-five percent of supplies

and 40 percent of the fuel for the war come via Pakistan.[51] It is estimated that 70 percent of all convoys consist of fuel and water resupplies, further illustrating the dependence that U.S. forces have on these supply arteries to fuel the war efforts.[52] The two main routes from Pakistan originate at the Karachi port. The main supply route from Pakistan into Afghanistan is from Peshawar via the Khyber Pass and on to Kabul. The other route crosses the border from Chaman, Pakistan to Spin Boldak, Afghanistan and on to Kandahar.[53] Approximately three times the number of supplies enter via the Khyber Pass as compared to the Chaman route.[54] Most of these deliveries are made by Pakistani and Afghan commercial contractors who contract for their own security firms.[55]

Although using outside contractors this way relieves pressure on the military to provide security and allows a smaller deployed military force to accomplish the mission, it is an exposed weakness. The success and security of these bloodlines, critical to the survival and success of U.S. forces, is essentially subcontracted to Afghan and Pakistani contractors. The graveness of the situation is evident in that the U.S. expanded the number of contracts to Afghan trucking and security companies by 600 percent in response to the warnings from these contractors that "service members will not get food, water, equipment, and ammunition they require."[56]

Although money solves the problem in this system, it is far from perfect. For example, in June 2008, 44 trucks and 220,000 gallons of fuel were lost to attacks or other events.[57] During that month, fuel consumed at Bagram Air Field exceeded the amount received due to these losses and delivery delays, illustrating how critical the continuity of the convoys is in sustaining operating forces given current consumption excesses at the FOBs.[58] Although the Afghan Transportation Ministry reported more than 60 trucks were destroyed or hijacked in 2008, this number is a low estimate given that most incidents go unreported.[59] Moreover, security guards

that the security firms provide to the convoy drivers are known to flee during attacks, leading many drivers to refuse to deliver military supplies any longer. Most Afghans feel that the only way to ensure lasting safety on the roads is to add military presence, which, given the hundreds of miles of currently unguarded routes, is impossible with current force numbers in theater.[60] Unfortunately, this situation is reminiscent of the capability gap felt by the lack of Soviet force numbers as previously discussed. According to one senior officer of a Pakistan-based trucking company, Taliban will stop at nothing to interrupt supplies going into Afghanistan, and 90 percent of his losses occur in Pakistan. In an average month, his company loses three tankers.[61]

The importance of these supply routes increases exponentially with President Obama's recent announcement to increase U.S. forces in theater by 30,000 troops this year, a fact not lost on the enemy. In February 2009, with news of an additional 35,000 troops to be deployed to Afghanistan, Pakistani Taliban blew up a bridge in the Khyber Pass, temporarily halting supplies from reaching their destination.[62] Over the course of 2009, there were 40 attacks on NATO supply trucks, the majority of which occurred in the Khyber and Chaman corridors between Pakistan and Afghanistan. More recently, in January 2010, Taliban broke new ground by attacking a NATO convoy in Karachi.[63] Days later, a fuel tanker bound for NATO forces was hit by a rocket in northwest Pakistan, causing a loss of 78,000 liters (20,600 gallons) of fuel.[64]

Numerous reports state that U.S. forces are dying on the roads daily in an effort to deliver supplies and fuel to the FOBs in Afghanistan.[65] This over exaggeration may stem from the resupply situation as it occurred in Iraq. For example, an Army study found that a 1 percent improvement in energy efficiency in Iraq would reduce the number of convoy missions by 6,444.[66] However, the Marine casualties in Afghanistan, as they relate to logistics resupply, are not enroute to the FOBs as is being purported; rather, the casualties occur in the convoys that

transport fuel from the main FOBs out to the smaller, more remote COPs. In fact, the convoys that bring fuel to the FOBs are handled by NATO convoys or Afghan or Pakistani contractors that transport fuel from the point of original sale to the Marines at camps, such as Dwyer or Leatherneck.[67] Marines then purchase the fuel from the contractors at $6.39 per gallon (based on August 2009 costs) and are then responsible for transporting the fuel to various COPs as needed.[68] Thus, contrary to popular belief, transporting fuel to COPs is where the threat to Marines who deliver fuel and supplies begins. Marines are at risk during the short, typical 35-mile convoy from the FOBs to the COPs. Statistically, of all the reported IED events in Helmand Province, about 8 percent were directed at logistics convoys such as these.[69]

The supply effort brings other unfortunate circumstances to the COIN effort. The continuous, seemingly endless, lines of trucks on the roads severely hinder the locals' use of the roads for daily business and free trade, which negatively affects local economies. Additionally, the convoys draw insurgent threats which threaten the security of local Afghans and Pakistanis and dissuade them from using the roads—the locals transit off-road through the countryside where they can to avoid the threat and go about their daily business. The sheer volume of heavy trucks and equipment has overburdened the roads, which are not built for this type of use, and caused permanent damage to infrastructure.[70] These factors go against COIN doctrine in terms of winning popular support, establishing a secure environment for the populace, protecting key infrastructure, and enabling a nation to succeed economically.[71]

Nevertheless, the real danger to the war effort exists at the strategic level, as the supply arteries are already approaching the limits of available throughput. There is a limit to the number of convoys that the road infrastructure through Pakistan and into Afghanistan can support. Logistics providers have already noted the inability to obtain critical items through the

supply system, such as equipment to properly produce and distribute electricity on FOBs. This difficulty stems from the limited number of convoys that can take up to 45 days to arrive at their destinations.[72] Consideration is given in some cases to airlift new or critical equipment due to backlogs. There simply is not enough throughput available on the roads—a problem that the Soviets who served in Afghanistan would relate to. What effect will the troop increase have on the already overburdened supply lines? "The pressure on supply lines will be enormous as we reach our ultimate numbers in Afghanistan."[73]

DoD Fuel Use – The Culture

One key finding of the 2008 DSB Report, "More Fight, Less Fuel," was that the military culture does not embrace energy efficiency.[74] The truth is in the numbers. The DoD is the largest single user of fuel in the United States. In 2008, the DoD purchased over 130 million barrels of petroleum, which equates to over 350,000 barrels of oil used per day.[75] In particular, approximately 300,000 gallons of jet fuel are delivered into Afghanistan each day, in addition to diesel and other types of required fuel.[76] The total of all fuels can be more than one million total gallons of fuel delivered per day.[77] Overall, FOBs' fuel consumption in combat zones has gone from 50 million gallons to 500 million gallons per year in the last five years, which is a ten-fold increase.[78] That fuel has always made it to the consumer, at the expense of enormous dollar costs, lives, and strategic damage. Until leaders make the connection between resource inefficiency and its cost to their efforts in a COIN campaign as well as combat power capacity attained through added efficiency, the culture of energy gluttony is unlikely to change.

Still much of the problem lies in lack of oversight at the appropriate level. Fixed DoD installations use about 25 percent of DoD's total energy. Energy use at these installations is regulated and managed by an on-site facility commander.[79] On the other hand, deployed systems

account for the remaining 75 percent DoD's energy use, and these costs are largely unregulated. In fact, the lowest level of command to regulate these expenses rests with the Deputy Secretary of Defense, an inappropriate level to provide effective oversight of this massive resource use.[80] Therefore, unless camp commandants or commanders have a personal interest in reducing fuel requirements and enforcing a standard to the warfighters, remedy is unlikely. Furthermore, authority to oversee and manage power consumption and expenses needs to be at the camp commandant level, as in permanent installations.

Ironically, the DoD's budget process actually discourages commanders from being efficient, which has perhaps contributed to this culture of inefficiency. For too long, commanders have been told to use all of their resources or they will lose the difference in funding for the next fiscal year. This "use it or lose it" mantra maintains the idea that dollars not spent in a commander's current budget will no longer be allocated in future budgets.[81] To remedy this situation, an incentive program that rewards efficiencies on deployed FOBs should be encouraged as a possible solution. This type of incentivizing is a practice aboard Navy shipping whereby conservation resulting in savings below a baseline level is redeemable for other ship improvements or programs.[82]

The Marine Energy Assessment Team (MEAT) Findings

> *There will be other Afghanistans – this is about Afghanistan but this is also about future ungoverned spaces [where] we will have to go.*[83] *USMC Commandant, General Conway*

On August 31, 2009, the MEAT was sent to Afghanistan to assess energy use by Marine forces, estimate the FBCF and Fully Burdened Cost of Water (FBCW), and recommend short-term energy savings. The team was sent by the USMC Commandant, General James T. Conway, due to his concern about supporting the "additional requirements coming into Afghanistan"

through "tenuous supply lines."[84] The team visited FOBs Dwyer and Leatherneck and found an immature but growing infrastructure and energy demand.[85]

The team determined that the daily requirement for fuel by the Marine Expeditionary Brigade-Afghanistan (MEB-A) was 88,749 gallons. Aviation use was almost half (40,687 gallons); power generation accounted for one-third (28,500 gallons); and "other," presumably tactical and non-tactical transportation, accounted for the remaining amount. Camp Leatherneck, a Marine FOB that was one of seven bases visited by the team, required an estimated total 36,740 gallons of fuel per day, or 10 fuel truckloads.[86]

The team further determined efficiency to be a significant problem for both power generation and power use. The daily power requirement was 5 megawatts (MW) at Leatherneck, and the 196 generators there were able to produce up to 19 MW. The team found that all 196 generators were running to meet the power demand; yet, each generator produced only 30 percent of its available load—a much less fuel efficient configuration.[87] The result was that 15,431 gallons of fuel were used each day to fuel the generators, which equating to 42 percent of Camp Leatherneck's overall consumption.[88]

That said, the team found the largest consumption of daily power was used for Heating, Ventilating, and Air Conditioning (HVAC) demands, at 3.75 MW of the total 5 MW, or 75 percent. The team assessed that at least 50 percent of heating or air conditioning was lost due to inefficient structures, representing a 1.875 MW loss in power production.[89] When translated into fuel use under the camp's configuration, HVAC requirements accounted for 11,573 gallons of fuel per day (32 percent of the total), or four truckloads. Of this total, 5,786 gallons, or two fuel truckloads worth of fuel, are wasted due to inefficient structures.

Additionally, the methods of funding were found to lead to inefficiencies, as the construction and maintenance of most FOBs was covered by Operations and Maintenance (O&M) funding instead of Military Construction (MILCON) funding.[90] O&M funding is typically used for minor construction spending, and such projects are typically restricted to $750,000.[91] This has led to reduced flexibility in the setup of the FOBs as well as restrictions on efficiency upgrades.[92] MILCON funding is approved for more permanent construction, but offers increased flexibility in energy efficient options.[93]

The team suggested an immediate option that would increase efficiency. This was to optimize the power grid layout of the generators, resulting in the ability to take two-thirds of the generators off line. This would require 65 generators running instead of 196, allowing a reduction in fuel use for power generation by 36 percent, equating to a daily savings of 5,557 gallons of fuel or two fuel truckloads per day. If efficiency measures such as foam or prefabricated structures could be added to the equation, the total daily estimate is reduced by 60 percent, or three fuel truck loads per day.[94]

The MEAT was able to uncover some extremely important issues at Camp Leatherneck. The quick efficiency options notwithstanding, providing HVAC to all spaces required 75 percent of the total power demands; this cost is astronomical. Additionally, there was one contractor for every two Marines, which means that one-third of the power demands are likely in support of the contractors who exist on Camp Leatherneck to provide many of the excesses. Other specific excesses were not addressed in the MEAT's report, but anecdotally, chow halls consume enormous amounts of power and could make great strides toward increased efficiency. Excessive reliance on contractors' comfort services and inefficient chow halls are two areas that deserve research. In a recent, related initiative, General McChrystal, Commander, U.S. Forces,

Afghanistan (USFOR-A), recently announced the closing of all fast food and retail outlets on FOBs, citing, "MWR (Morale, Welfare, and Recreation) programs across the theater should be limited in scope and tailored for an expeditionary force."

The Mindset

> *The expeditionary mindset implies a Spartan attitude: an expectation and a willingness to endure—in fact, a certain pride in enduring—hardships and austere conditions. As an example of this attitude, embarkation boxes substitute for bookcases, even in garrison, and creature comforts are minimal.*[95] *MCDP 3, Expeditionary Operations*

According to the current USMC Commandant, expeditionary means being "fast, austere, and lethal."[96] In the Afghanistan theater, "fast" and "lethal" are more applicable to offensive operations conducted against the enemy. "Austere," to the commandant, means that Marine forces should be efficient with what they have.[97] As the MEAT study showed, there are some quick improvements in this regard that can produce immediate, measureable results. Until other technological solutions can arrive in theater, the features and benefits of which will be discussed later, the next step is to address the loss in expeditionary mindset that comes about as soon as consolidation on an objective begins. In this case, those objectives are the FOBs, the places in Iraq where Marine forces became a "second land army."[98] Arguably, the FOBs in Afghanistan will evolve to support a similar mindset without the leadership to change it.

One of the challenges in changing the mindset of Marines toward greater fuel efficiency is derived at home, in the U.S. Marines associate fuel conservation with the "green" movement, which has a poster boy that is anything but a role model for Marines. If "driving the Prius" in combat meant not causing fellow Marines to be killed or wounded, perhaps Marines would accept the concept. Perhaps being "green" in combat can be equated to the expeditionary, Spartan attitude; enduring austerity that the commandant mentioned for the good of fellow

Marines, the mission, and to combat the strategy of the enemy as he attacks supply lines in an effort to strangle dependent forces.

If expeditionary Marines knew that many of the comforts enjoyed at the FOBs directly funded the enemy they currently face daily on the battlefield, perhaps the HVAC would not feel so cool, or the plentiful, hot food would not taste as good, or they would hesitate to buy the plasma TV from the Exchange to enjoy in their "can."[99] If Marines fully appreciated that every watt of power was produced by gallons of fuel that likely originated with a hostile, terrorist-funding regime that they have been abroad fighting for almost a decade now, perhaps a greater number of Marines would embrace expeditionary efficiency.[100] The irony is this: increased excesses breed a wealthier Taliban and thus, greater recruitment, popular support, and momentum to his movement—fuel feeds not only lifestyles and combat power, but the enemy and his strategy as well.

Indeed, taking trucks off the road not only saves lives, but it takes away targets for the enemy, which reduces his strategy—his bid for success. Attacks on convoys that fuel U.S. forces keep the rate of replenishment at a dangerous balance between supply and demand. This type of enemy counts on the typical American "addiction to oil," even by those deployed in a combat zone. Inefficient use of resources brings targets to the enemy at an ever-increasing rate, and hitting targets ensures that even more targets will desperately come. Marines need to understand these relationships to fully comprehend the nature of the enemy they face. It is not only at the "tactical edge" that Marines can take the fight to, or away from, the enemy.

To realize these advantages found through conservation, Marines will have to renew the Marine pride in the mantra, "more for less." That phrase is understood by Marines, and while a common complaint, Marines know deep down inside that they take pride in living the concept

and living as expeditionary as possible. Marines should take offense in being referred to as a "second land army." Marines who live on the COPs at the tactical edge do not get anywhere near the luxuries that the FOB dwellers do, and they are the ones under constant threat. To illustrate, the fuel use at Camp Leatherneck was almost three gallons per day per Marine for power demands alone in August 2009.[101] By comparison, COP Jugroom fuel use was about 17 percent of that, at only 0.5 gallons per day per Marine.[102] These COP-dwelling Marines are taking the fight away from the enemy with this type of living.

It is up to leadership to solve this problem, to instill in Marines the knowledge and purpose to live as Marines, for Marines. As Sergeant Major Carl Green of II Marine Expeditionary Force remarked, if upper-level leadership makes energy conservation a priority, Marines will go a long way in creating innovations at their level.[103] Thus, from MCDP 3, "This mindset (expeditionary) is a matter of training and institutional culture. Commanders must realize the continuous importance of imparting and maintaining this attitude within their units"[104]

Troop Increase Implications

> *When provisions are transported for a thousand li expenditures at home and in the field, stipends for the entertainment of advisers and visitors, the cost of materials such as glue and lacquer, and of chariots and armour, will amount to one thousand pieces of gold a day. After this money is in hand, one hundred thousand troops may be raised.*[105]
>
> *-Sun Tzu*

The problem deepens. For each fuel truck on the roads in the Marine convoys, an average of 18 other vehicles accompany it. This includes security, repair, water, logistics, and miscellaneous cargo trucks. Accounting for the fuel consumption of these 19 vehicles, each seven gallons of fuel delivered to a COP requires one gallon to deliver that fuel.[106] Thus, when considering an action that consumes the equivalent of seven fuel truckloads per day, it is important to remember that this means one extra fuel truck on the road per day, and as many as

seven per week. If this convoy travels 550 miles roundtrip, each fuel trucks' worth of fuel delivered requires an extra fuel truck to make the journey due to accompanying vehicles.[107]

For Afghani and Pakistani contractor convoys that deliver fuel to Camp Leatherneck, the convoy composition varies. Table 2 shows that for every 17 fuel trucks traveling 774 miles (the approximate one-way distance traveled on roads from Karachi, Pakistan to Camp Leatherneck), one full fuel truck's worth of fuel is burned. This calculation is conservative as it does not take into account escort or support vehicles accompanying the convoy, as the ratio of escort and support vehicles to fuel trucks vary by contractor and mission.[108] This simply illustrates that when an action (such as a troop increase of 30,000) calls for additional trucks of fuel, the implication may be much larger than it appears on the surface.

When looking at data figured for fuel use per soldier or Marine per day, the implications are astounding. However, the sources vary. According to a Deloitte LLP study, current fuel consumption is about 22 gallons per soldier per day, which continues to grow (see Figure 2).[109] Simple math shows that for a troop increase of 30,000, the implication is a daily fuel increase of 660,000 gallons, or 174 additional fuel trucks on the road daily. Using the previously mentioned 7 to 1 ratio for fuel delivery, this is 200 total fuel trucks. When considering the FBCF in this discussion, at $12 per gallon, the 660,000 gallon daily increase would cost the DoD over 9 million additional dollars per day in fuel costs. Even without the benefit of this analysis, it is not difficult to imagine that with a large troop surge, there will be a corresponding increase in daily logistics convoys, which leads to higher fuel costs, higher casualties, and an increase in the previously noted damage to the COIN strategy. It highlights the immediate need for greater efficiency and conservation.

The exact calculations that were used to determine the 22 gallons per soldier per day are unknown. Using Deloitte's own figure of 30.4 million gallons of total fuel use in Afghanistan per month and a troop number of 68,000, the figure becomes 14.9 gallons per soldier per day.[110] However, these numbers appear to consider all demands for fuel, including aviation and ground vehicles. When considering that power generation alone currently requires, on average, about one-third of all fuel at a FOB, the result becomes roughly 5 gallons per soldier per day.[111] At Camp Leatherneck, the number was 2.6 gallons, and for MEB-A as a whole, it was 1.9 as of August 2009.[112] Clearly, the number varies with service branch and the function of the FOB in question. Using 5 gallons per soldier per day, the troop increase by 30,000 will require 150,000 gallons of additional fuel, or 49 fuel trucks (7 to 1 ratio factored in), per day. At $12 per gallon, this will come at an additional cost of $2.1 million per day for power generation fuel alone. However, if all of the additional troops are as "expeditionary" as the COP Jugroom Marines from the previous section, they will only use 0.5 gallons per service member per day. Instead of 150,000 gallons additional per day, the total would be 10 percent of that, at 15,000 gallons. This is only five fuel trucks per day instead of 49.

IV. Potential Solutions and Initiatives

> *The grade we would give our expeditionary forces is 'not so good' due to wastefulness...*[113] *General Conway, USMC Commandant*

Expeditionary operations are, by definition, temporary, and this fact is a common cause for the lack of efficiency built into our FOBs.[114] Many camp commandants have been hamstrung by the fact that their camp is "expeditionary" and cite this as the reason for not upgrading to more efficient, but also more permanent, measures such as tent foaming.[115] Given modern innovations in expeditionary efficiency, it is now possible to provide our forces with solutions that are both energy efficient, easily deployable, and feature rapid set-up and tear-down.

It is possible to maintain or increase operational flexibility during this period of increasing troop numbers in Afghanistan by reducing the "per man" use of resources. The solution will involve the full spectrum of changes to behavior, leadership, oversight, and technology. Key recommendations follow:

1. Identify and eliminate key excess comfort items that bring the most savings
2. Evaluate all FOBs and COPs with a purpose similar to that of the MEAT in order to identify immediate quick fixes
3. Introduce the appropriate level of oversight, monitoring, enforcement, and reporting at all expeditionary FOBs and COPs
4. Appeal to leaders and Marines to better understand and value conservation
5. Introduce major technological upgrades to power generation, distribution, and efficiency of structures and shelters.

The last item will be discussed here. When considering the options, certain characteristics will help to prudently design the "system of systems." As previously stated, FOB HVAC pulls the vast majority of power due to inefficient structures and tents. It is therefore prudent to first address the inefficiency of structures before attempting to meet power demands through renewable energy. For example, Camp Leatherneck's five MW daily power demand could be greatly reduced with more efficient structures. Once HVAC demand has been reduced, it can then be matched with upgrades in power production using maximum use of renewable power sources feeding battery micro-grids.

When considering renewable energy options, it is important to understand that renewable solutions such as wind and solar energy can never be relied upon to deliver a constant power output. For instance, if the demand is a constant 10 kilowatts (kW) of power, a 10 kW rated

generator can meet that demand, assuming it is constantly fueled. However, a renewable source that advertises 10 kW at peak can only meet the 10 kW demand under ideal conditions (i.e., during peak sun or high wind conditions), and then only for a short time. Key characteristics when considering power generation technologies are to ensure that the systems include:

1. Modularity and scalability. As a FOB grows and supports more troops, it is important to be able to add systems onto the grid.

2. Power storage/distribution capability. A system that is able to store and distribute power generated from a variety of sources is essential. A grid that includes modern battery storage is possible with current technology. This would allow multiple alternative energy sources to store power to the grid. The Army has estimated that the use of smart "microgrids" added to current FOBs would reduce energy consumption by 25-40 percent.[116] Additionally, power storage allows renewable solutions to meet higher peak demands for longer periods.

3. "Smart demand." A system that is able to automatically switch backup generators on and off as additional power is needed could save enormous amounts of fuel, as opposed to current methods of running generators around the clock regardless of demand variations.

As the Commandant stated, "the goal is to be self-sufficient",[117] thus maximizing our expeditionary nature. The solution at the tactical edge is for Marines there to keep living hard, but they should also be supplied with state of the art, expeditionary, renewable solutions so that they can turn off diesel power generation, store it for back up use, and have a net-zero COP. This can bring about significant reductions in the number of Marine fuel convoys that travel from the FOB to the COP, which is currently about two per week in a MEAT studied example.[118] While a net-zero FOB may extremely challenging, that should always be the goal that is never deemed impossible. With this in mind, the systems below meet the above characteristics.

Selected Industry Solutions

Energy Technologies, Inc (ETI)/Utilis Shelters

Utilis and ETI have partnered in order to provide a modern, efficient shelter system paired with multiple power production options. The shelters are transportable via HMMWV by section, quickly erected in under five minutes and feature a state of the art folding frame design. With an external thermal fly covering that allows a layer of air to act as an insulator, the system has proven a 26 percent increase in efficiency when compared with standard tents.[119] By comparison, tent foaming offers a 20-40 percent reduction in HVAC demands, although it has been criticized for ruining a tent once it has been applied.[120] The ETI system also features solar panels integrated onto the thermal fly, which produced over 4 kW of power at peak in testing at Holloman AFB in September 2008.[121] This is power that could be added to the power storage microgrid. Assuming anywhere from 1-4 kW per hour per shelter and a 10-12 hour day, that could add up to a significant amount of kW-hours of power added to the grid.

ETI offers a complete system of power production options to go along with the shelter system, including a Tactical Power Plant (TPP), Tactical Wind Turbines (TWT), Tactical Fuel Cells Power Plant (FPP), Tactical Enviromental Control Units (ECU), as well as Tactical Generators. A tactical microgrid controller automatically selects between available power sources based on efficiency and load demand, and manages loads based on priorities and available power sources. The TPP can accept power from multiple power sources including local grid power in AC or DC, vehicle power, or the ETI Tactical Generator. The built in power conditioner regenerates power into computer or medical grade power. The Tactical FPP uses Metal Hydride fuel cells. Fuel canisters can be added to allow additional runtime. These can each produce 1.5kW, or can be stacked to produce in the 1-5 kW range. Each Tactical Wind

Turbine (TWT) can produce up to 1200 watts and is mounted on a telescoping, rotatable mast. The entire system, including solar panels integrated with four Utilis shelters and 3 TWTs can produce 20kW of power at peak sunlight and optimum winds, with backup power available from the TPP or FPP.[122] Perhaps the best feature of this system is that it not only includes all of the previously mentioned key characteristics for power generation and storage, but it is also integrated with a state of the art shelter system that feeds power into the grid.

Shift Power Solutions

Shift Power Solutions offers "Life in a Box". The system itself is a modular, scalable "system of systems," that features a water purification system, communications system, power system, and waste disposal. It is designed for long-term use in rugged conditions and requires minimal training and low maintenance. [123] According to the representative, a 60 percent reduction in fuel use can be achieved just by pairing current generator inputs with the state of the art, Lithium ion battery storage system since it also features the ability to shutoff generators that are not needed based on current demands.[124] The characteristics advertised by the Shift "Power Family" are modularity, scalability, and interconnectivity. The core power module is the central hub for energy management and power generation. It accepts power in all forms of DC and AC, regardless of source, and then provides conditioned AC power. Primary sources of power are solar and wind, but it has an internal 3kW fossil fuel generator for continuous power. The system is available in 35, 70, and 100 kW-hour configurations. It is designed to be a standalone unit with no grid-tie in but is also a storage bridge that can be added to existing generator sets. [125]

One of the greatest features of the system is that it is rugged and compact in its storage and shipping configuration as well as its deployed configuration. In storage mode, it has the appearance of a standard shipping container. The battery packs are enclosed, but slide out for

easy maintenance. The solar accessory module is comprised of four solar accessory packs, each of which has twelve 230 Watt panels to generate a total of 2.7 kW peak, for a total of 11kW. The solar panels are stored in the top in storage or transport configuration, and the system is easily set up in 20 minutes. Solar packs can be added as needed to meet higher demands.

Solar Stik

With typical power requirements of 3 kW continuous at smaller COPs such as Jugroom, the Solar Stik system is a perfect design to meet these power requirements.[126] Weighing only 101 pounds, the system features two 50 watt solar panels that attach to an aircraft-grade aluminum and stainless steel mast that erects a 200 watt wind generator. The wind generator can revolve for optimum winds and the solar panels can rotate for optimum solar power production. The system is paired with an advanced 1 kW Lithium ion battery storage system, the "Power Pak 100," that can accept power from the solar and wind system as well as generators. The Power Pak can automatically turn generators on and off to meet demands as needed. Additional Solar Stik systems are available for different sized needs. The system is simple, easy to operate, requires minimal maintenance, and can be set up by one person in under 10 minutes.[127]

Testing Initiative

The Experimental FOB (ExFOB)

> *Mission: An ExFOB will be established at MCB Quantico in order to simulate OEF energy and water demands and to evaluate material and non-material solutions that will increase forward operating base self-sufficiency.*[128]

Given the multiple systems that industry offers to address the Marine Corps' expeditionary energy needs, an ExFOB is being built on Marine Corps Base Quantico. The ExFOB is a joint project between Marine Corps Warfighting Lab (MCWL), the Office of Naval Research (ONR), Marine Corps Combat Development Command (MCCDC), Marine Corps Systems Command (MARCORSYSCOM), and the newly established Marine Corps

Expeditionary Energy Office (E2O).[129] The intent is to design and build a distributed platoon/standard company sized, scalable FOB prototype "by the book," that is, according to the specifications outlined in the Sandbook[130] for building a FOB. The project will be conducted in phases, the ultimate end state being the selection, training, and deployment of expeditionary energy production, shelter, and water purification systems for an Extended User Evaluation (EUE) in the Afghanistan Theater.[131]

Phase One's purpose was ultimately to determine a baseline power demand from which to measure "effectiveness and efficiencies gained from material and non-material solutions." It focused on FOB energy consumption of things such as electronics, shower/laundry pumps, water production, and shelter. [132] Phase One was completed from February 15-19, 2010.[133]

Phase Two's purpose is to evaluate Commercial-Off-The-Shelf (COTS) technology for inclusion in an EUE. The intent is to identify immediately available solutions to offset the power requirements of a FOB as well as to develop Tactics, Techniques, and Procedures (TTPs) for incorporation of COTS solutions. The performance of competing systems will be measured and recorded for possible future procurement.[134] Phase Two began on February 22, 2010 and was completed on March 17, 2010.[135]

The purpose of Phase Three is to allow a Marine unit preparing to deploy to Afghanistan the opportunity to conduct hands-on training and familiarity with the equipment selected during Phase Two. That unit will then conduct the EUE during its seven-month deployment, and provide feedback upon return. The date for Phase Three has not yet been determined.[136]

Phase Four is planned for August 2-13, 2010. The ExFOB will reopen and allow additional industry demonstrations to take place under the same conditions as Phase two.[137] The

purpose of this phase is to collect data on experimental systems that were immature at the time of Phase Two, and allow continued refinement of long term solutions for expeditionary systems.[138]

Some general characteristics that MCWL and E2O are looking for are that systems are transportable via small tactical vehicle, use microgrid power storage and distribution, are mobile and reusable, energy efficient, simple to operate, easy to maintain, and ideally offer leave behind solutions for host nations.[139]

V. Conclusion

Why should expeditionary forces improve energy efficiency in Afghanistan? Because they *have* to. The FOB mega-cities that came to be in Iraq are not going to work in Afghanistan. Yet it seems that U.S. forces are using them as a model for how to live in an austere, expeditionary combat zone. They run counter to the very nature of counterinsurgency and the renewed strategy in Afghanistan as outlined by General McChrystal. The requirements to fuel these FOBs have pushed the bloodlines that feed them to their maximums and have taxed the infrastructure and host nation supporters to the point of breaking. Enormous fuel use not only profits unstable, extremist regimes that fund terrorism, but payments for its delivery have been shown to feed the insurgent enemy that our forces are fighting and provide them with a steady stream of targets. Furthermore, the successful delivery of fuel and supplies is not assured in exchange for the byproduct damage to the COIN effort, and the upcoming troop increase will serve to exacerbate these issues at a high cost in dollars.

Worse, the Marines at the tactical edge depend on their trickle of fuel that makes it out to the end of the supply chain, where they take the fight to the enemy. These Marines at the COPs live without the comforts of the FOB dwellers. The needs of these Marines are kept to a minimum—Marines (as opposed to Afghani or Pakistani contractors) are the ones at risk

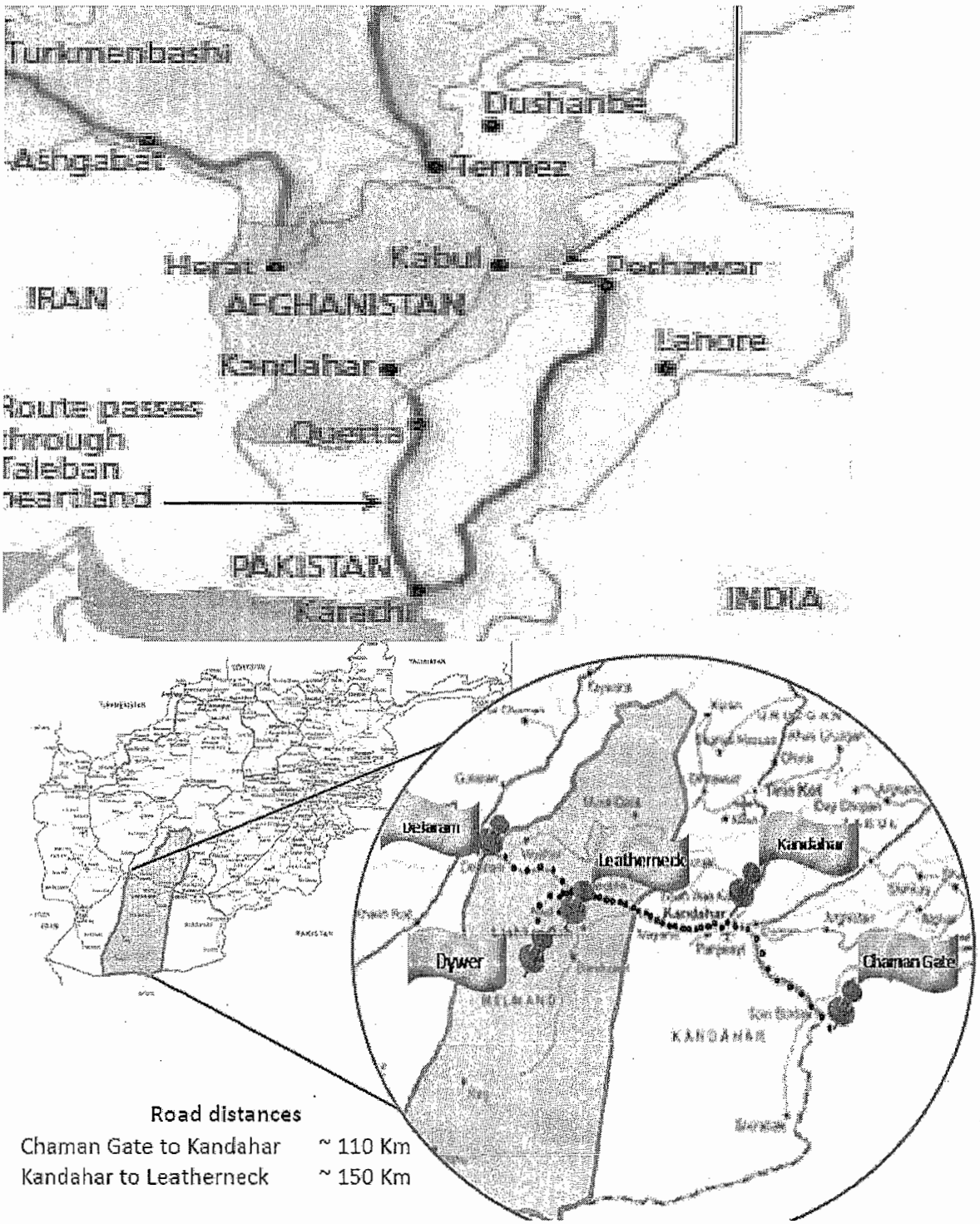
delivering the fuel, water, and supplies. As such, their energy requirements are small and could be met solely by upgrading current equipment and adding renewable power solutions, which could virtually put a stop to their continued needs for fuel to produce power.

The argument that expeditionary efficiency needs improvement because each gallon of delivered fuel costs $400 is not only incorrect, but also does not strike at the heart of the problem, nor reach the hearts of the war fighters. To Marines, it is the cost of doing business. Marines would react if they knew that the fuel supply were at risk of shut-off, as would be the case if the tenuous, limited supply line were cut off by the enemy, or the Afghani or Pakistani contractor support folded, or the infrastructure became too overburdened. Marines would care if they knew that their actions brought funding to the continued efforts and growth of their enemy.

Marines are taught to "live hard" from day one at boot camp or Officer Candidate School. Featuring the closest identification with their historical, proud roots dating back to 1775, Marines still identify with the legends of the past who fought and won wars without a trace of the comforts available to the warfighter in the field today. However, Marines are also human and can fall into a garrison-like routine complete with the vices of home if surrounded by them. Deep within the city-like FOB, it is easy to lose touch with how all of the items are made available, and what it means to have them there. The little morale-building items that Marines come to rely on to pass time or remind them of home could potentially be causing the death or injury of other Marines, hurting the war effort as a whole, or causing limitations in operational flexibility or sustainment of future force buildups—this is a connection that Marines want to understand. Even when they are not off the FOB and personally taking the fight to the enemy with a rifle, they want to help win the war in any way they can. Deep down inside, they want to live hard at war like those that have gone before, as proud Marines.

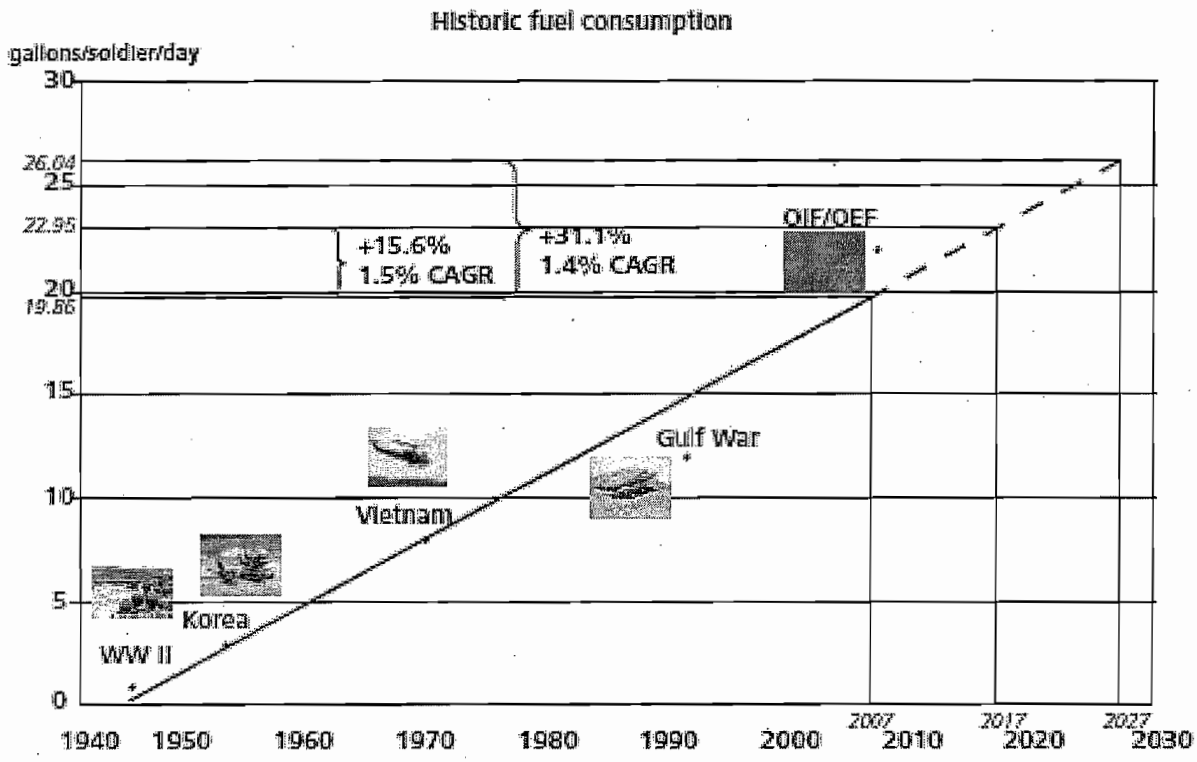
APPENDIX A: ILLUSTRATIONS

Figure 1. NATO Supply Routes[1]



[1] MEAT Assessment, January 26, 2010.

Figure 2: Historic DoD Fuel Consumption[1]



Source: DESC, Rand Corporation, AMSAA, Deloitte Analysis
Y=0.3091X-600.51. R-squared: 0.9517.

[1] Deloitte Report, 3.

APPENDIX B: TABLES

Table 1. Expeditionary FBCF Calculation

Each CH-53E:	
TBFDS tank capacity (lbs useable fuel)	5440
TBFDS pump rate (pounds fuel/minute)	300
Fuel burn per Ch-53 in flight (lbs/hour)	3600
Fuel burn per Ch-53 on ground, idle (lbs/hour)	1800
Fuel burn per CH-53 on APP[1] only (lbs/hour)	80-180

		CH-53 (1)	CH-53 (2)	CH-53 (3)	CH-53 (4)
Starting fuel (lbs)[2]		24800	24800	24800	24800
Fuel burned in flight enroute, one way (4xCH-53)[3] (lbs)		9800	9800	9800	9800
Total fuel burned on ground giving fuel to AH-1Ws[4,5] (lbs)		1800	1800	1800	1800
Total fuel pumped to AH-1Ws on ground[6] (lbs)		2700	2700	0	0
Fuel burn while pumping to FOB bladders (APP) (lbs)		30	30	75	75
Fuel required for return flight (lbs)		9800	9800	9800	9800
Fuel remaining to give to FOB (lbs)		670	670	3325	3325
Total fuel given to FOB (lbs)					7990
Total fuel given to FOB (gallons)					1175
Total gallons used, all considered					15088
Cost of total fuel (at $4.93/gal)[7]					$74,385
Total flight time of 4xCH-53s (at 7 hrs each)[8]					28
Cost of CH-53 flight hours, at $10,400 per hour[9]					$291,200.00
Total flight time of 2xAH-1Ws (at 7 hrs each)[8]					14
Cost of AH-1W flight hours, at $4,500 per hour[9]					$63,000.00
Total costs					$428,585.00
Cost per gallon (considering FBCF)[9]					$364.75

[1] Auxiliary Power Plant

[2] 10,880 useable in the two onboard TBFDS tanks plus 14,000 lbs in the internal tanks. Lee, Maj Isaac, Command and Staff Student, personal interview with author, I

[3] Assuming 3600 lbs/hour burn rate in flight

[4] All four CH-53s remain turning for tactical reasons

[5] 30 minutes each TBFDS session, 2 for entire trip

[6] 1700 lbs taken enroute to FARP, 1000 lbs on return trip

[7] Using DSB, "More Fight" fuel costs for ship-delivered fuel as the original source for all aircraft, and converting it to 2010 dollars, the cost is $4.93/gal (using time value of money rates from Fully Burdened Costs Presentation).

[8] Time turning on ground while refueling is included

[9] Fully Burdened Costs Presentation

[10] Total costs divided by total fuel delivered to FOB yields this figure

Table 2: Fuel truck Distance/MPG Calculation

Inputs:

Karachi-Chaman[1]	987 km (613 mi)
Chaman-Kandahar[2]	110 km (68 mi)
Kandahar-Leatherneck[2]	150 km (93 mi)
Total Distance	1247 km (774 mi)
Total Distance (miles)	774
Gallons per truck	3500

	Type	Burn Rate (mpg)	Miles	Gals per veh
1	M970 (Fuel)	3.8	774	204
2	M970 (Fuel)	3.8	774	204
3	M970 (Fuel)	3.8	774	204
4	M970 (Fuel)	3.8	774	204
5	M970 (Fuel)	3.8	774	204
6	M970 (Fuel)	3.8	774	204
7	M970 (Fuel)	3.8	774	204
8	M970 (Fuel)	3.8	774	204
9	M970 (Fuel)	3.8	774	204
10	M970 (Fuel)	3.8	774	204
11	M970 (Fuel)	3.8	774	204
12	M970 (Fuel)	3.8	774	204
13	M970 (Fuel)	3.8	774	204
14	M970 (Fuel)	3.8	774	204
15	M970 (Fuel)	3.8	774	204
16	M970 (Fuel)	3.8	774	204
17	M970 (Fuel)	3.8	774	204

Total Gallons burned:	3463

[1] http://maps.google.com/

[2] MEAT Assessment, January 26, 2010.

Notes

[1] A "li" is a traditional Chinese unit of length, often used when discussing distance. Joseph Needham claimed that during the Qin and early Han Dynasty the *li* was 0.4972 km (0.309 mi). However, more recent and reliable determinations show that during the Early and Later Han dynasties the value of the Chinese *li* was 0.4158 km (0.25837 miles). Source: http://en.wikipedia.org/wiki/Li_%28length%29

[2] Samuel B. Griffith, *Sun Tzu: The Art of War.* (New York: Oxford University Press, 1963), 75.

[3] Headquarters U.S. Marine Corps, *Expeditionary Operations,* MCDP 3 (Washington, DC: U.S. Marine Corps, April 16, 1998), 43.

[4] Defense Science Board Task Force, *Report of the Defense Science Board Task Force on DoD Energy Strategy, "More Fight – Less Fuel"* (Washington, DC: Defense Science Board, February 2008), 44. Cited hereafter as DSB, "More Fight".

[5] Government Accountability Office, *DOD Needs to Increase Attention on Fuel Demand Management at Forward-Deployed Locations* (Washington, DC: Government Accountability Office, February 2009), 14. Cited hereafter as GAO Report.

[6] Col Thomas C. Moore, USMC, Military Assistant to the Director and Commandant of the Marine Corps (CMC) Operational Liaison, Defense Advanced Research Projects Agency (DARPA), "Marine Energy Assessment Team (MEAT): Afghanistan Assessment Outbrief" (Powerpoint Presentation for CMC, October 1, 2009). Cited hereafter as MEAT Outbrief, October 1, 2009.

[7] Col Thomas C. Moore, DARPA Liaison, conversation with author while attending USMC Expeditionary Energy Symposium, New Orleans, LA, January 27, 2010.

[8] For purposes of this study, the term "efficiency" will refer to equipment in terms of its ability to produce the desired result with minimal fuel or waste. "Conservation" will refer to human behavior and practices that minimize waste of resources.

[9] DSB, "More Fight", 29.

[10] DSB, "More Fight", 29-30.

[11] David C. Isby, *War in a Distant Country Afghanistan: Invasion and Resistance* (London: Arms and Armour Press, 1989), 16-24.

[12] Mark Urban, *War in Afghanistan,* 2nd ed. (Houndmills, Basingstoke, Hampshire, and London: The MacMillan Press LTD, 1990), 41.

[13] The Russian General Staff, *The Soviet-Afghan War: How a Superpower Fought and Lost,* ed. Lester W. Grau and Michael A. Gress, trans. Lester W. Grau and Michael A. Gress (Lawrence, Kansas: University Press of Kansas, 2002), 15-34.

[14] Lester W. Grau, email conversation with author, Lester W. Grau, January 14, 2010 and March 19, 2010.

[15] Lester W. Grau, *The Bear Went Over the Mountain: Soviet Combat Tactics in Afghanistan* (Washington DC: National Defense University Press, 1996),74-75, cited hereafter as Grau, "Bear," and Urban, 191.

[16] It is important to note that multiple sources make mention of "siege" on government centers and outpost garrisons. This seems to indicate, in varying degrees, either isolation from outside supply or isolated incidents of mortar fire or rocket attacks, but not necessarily imminent overrun. The relief of these "sieges" could simply mean taking pressure off wearying defenders or in fact saving the garrison from being overrun.

[17] Urban, 229.

[18] Urban, 174.

[19] Urban, 229-230.

[20] Grau, "Bear," 60-61, and Ali Ahmad Jalali, and Lester W. Grau, *Afghan Guerrilla Warfare: In the Words of the Mujahideen Fighters* (St. Paul, MN: MBI Publishing Company, 2001), 168-170.

[21] Jalali, 170-172.

[22] Jalali, 172.

[23] Grau, "Bear," 202-203.

[24] Colonel Thomas C. Moore, USMC, Military Assistant to the Director and Commandant of the Marine Corps (CMC) Operational Liaison, Defense Advanced Research Projects Agency (DARPA), personal interview with author, February 24, 2010. Cited hereafter as Col Moore interview.

[25] DSB, "More Fight", 29.

[26] FBCF is used interchangeably with Assured Delivery Price (ADP) in this study. There are indications found in researching the concepts that FBCF will be used in the future to represent costs of end user platforms in $/day of delivered fuel while ADP will remain in $/gallon at the delivery platform drop off point (initial FOB of delivery). FBCF includes any additional costs beyond initial delivery, such as subsequent delivery to a follow on combat outpost (COP) or other infrastructure costs.
[27] DSB, "More Fight", 16.
[28] Sandra I. Erwin, "Gargantuan Thirst for Fuel Creates Logistical Nightmare for Marines," *National Defense Magazine*, December 2009, http://www.nationaldefensemagazine.org/ARCHIVE/2009/DECEMBER/Pages/GargantuanThirstforFuelCreatesLogisticalNightmareforMarines.aspx (accessed January 11, 2010), and Roxana Tiron, "$400 per gallon gas to drive debate over cost of war in Afghanistan," *The Hill*, October 15, 2009, http://thehill.com/homenews/administration/63407-400gallon-gas-another-cost-of-war-in-afghanistan- (accessed March 15, 2010).
[29] DSB, "More Fight", 12.
[30] DSB, "More Fight", 15.
[31] DSB, "More Fight", 16.
[32] Aram Roston, "How theU.S.Funds the Taliban," *The Nation*, November 11, 2009, http://www.thenation.com/doc/20091130/roston (accessed January 14, 2010).
[33] DSB, "More Fight", 28.
[34] DSB, "More Fight", 30.
[35] General James T. Conway, *CMC Remarks, USMC Energy Summit*, (Washington D.C.: August 13, 2009), cited hereafter as CMC, August 13, and Carla Lucchino, "The Energy Conversation" (Multiple Service briefings, L'Enfant Plaza Hotel. Washington, DC, October 19, 2009), and Defense Science Board Task Force, *More Capable Warfighting Through Reduced Fuel Burden,* (Washington, DC: Defense Science Board, January 2001), 19. Cited hereafter as DSB, More Capable.
[36] DSB, More Capable, 19.
[37] DSB, More Capable, 19.
[38] DSB, "More Fight", 30.
[39] The 35 mile distance was based on a typical distance from a FOB to a COP in Afghanistan currently. Afghan or Pakistani contractors, such as Supreme Trucking, deliver the fuel to the FOB and Marine convoys then transport the fuel from there to various outlying COPs, a.k.a., the "tactical edge" from MEAT Outbrief, October 1, 2009. Incidentally, the USMC Vision & Strategy 2025 study concluded that by 2025, 70% of the world's population will live within 35 miles of a seacoast, which is where Marines are expected to fight (Included in CMC, August 13).
[40] Edward Blankenship (PA&E) and Randal Cole (CNA), Headquarters Marine Corps P&R. "Fuel and Water for OEF: Towards Developing 'Fully Burdened Costs'" (Powerpoint presentation for CMC, December 4, 2009). Hereafter cited as Fully Burdened Costs Presentation.
[41] Fully Burdened Costs Presentation.
[42] Fully Burdened Costs Presentation.
[43] Fully Burdened Costs Presentation.
[44] Perhaps it is important to note that if each CH-53E took 1000 lbs less fuel from takeoff than in this calculation, very possible depending on meteorological conditions, the amount of fuel delivered to the COP is less than 600 gallons (less than 50%), with a fully burdened cost that doubles, at $725.48 per gallon.
[45] Brookings Report, 2, and Fully Burdened Costs Presentation, and www.imprintmodels.co.uk/pdf/3/37_lavspecs.pdf (accessed March 10, 2010). LAV-25 fuel consumption is 4.5 mpg, up armored HMMWV is 4 mpg, MRAP is 3 mpg, and each AH-1W uses 250 gallons per 2 hour flight.
[46] Major Richard B. Ashford, telephone interview with author, March 10, 2010. Maj Ashford is a current Command and Staff student, but participated in Operation ANACONDA with the 13th MEU as an AH-1W pilot. According to Maj Ashford, the Army 10th Mountain Division formed the command element for the TF, hence the name "TF Mountain."
[47] Ashford.
[48] http://www.strategypage.com/articles/tf58/sustainment.asp (accessed March 10, 2010).

[49] CMC, August 13, and Lucchino.
[50] GAO Report, 7.
[51] Robert Birsel, and Jerry Norton, ed, "FACTBOX: Afghan Supply Routes: Problems and Possibilities," *Reuters*, February 3, 2010, http://www.reuters.com/article/idUSTRE5121FU20090203 (accessed February 5, 2010).
[52] GAO Report, 8.
[53] Ben Farmer. "Khyber Pass Bridge Used By NATO is Blown Up By Militants," *Telegraph*, February 3, 2010, http://www.telegraph.co.uk/news/worldnews/asia/pakistan/4448121/Khyber-Pass-bridge-used-by-Nato-is-blown-up-by-militants.html (accessed February 4, 2010).
[54] Reuters.
[55] GAO Report, 8, and Col Moore interview.
[56] Roston.
[57] GAO Report, 8.
[58] GAO Report, 47.
[59] Soraya Sarhaddi Nelson, "Afghan Convoys Risk Taliban Attacks," *NPR*, Jan 30, 2009. http://www.npr.org/templates/story/story.php?storyId=99822151 (accessed February 4, 2010).
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[61] Julie McCarthy, "Pakistani Truckers Ply Risky Road to Afghanistan," *NPR*, February 3, 2010. http://www.npr.org/templates/story/story.php?storyId=123269200 (accessed February 4, 2010).
[62]Habibullah Khan, and Nick Schifrin, "U.S.-Afghan Supply Line Out of Business Again," *ABCNews.go.com*, February 3, 2009. http://abcnews.go.com/International/story?id=6793956&page=1 (accessed February 5, 2010).
[63] Robert Inks, "Pakistan: NATO Supply Trucks Attacked in Karachi," *Stratfor.com*, January 28, 2010. http://www.stratfor.com/analysis/20100128_pakistan_nato_supply_trucks_attacked_karachi (accessed January 28, 2010).
[64] Kelly Polden, "Pakistan: Militants Torch NATO Tanker," *Stratfor.com,* February 1, 2010. http://www.stratfor.com/sitrep/20100201_pakistan_militants_torch_nato_tanker (accessed February 5, 2010).
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[66] Brookings Report, 3.
[67] Col Moore interview.
[68] MEAT Outbrief, October 1, 2009.
[69] Col Moore interview.
[70] Col Moore interview.
[71] U.S. Department of the Army and Headquarters U.S. Marine Corps, *Counterinsurgency,* FM 3-24 or MCWP 3-33.5 (Washington, DC: U.S. Department of the Army, December 2006), 1-29.
[72] Colonel Robert J. Charette, "Expeditionary Efficiency," (Lecture, Command and Staff College, Quantico, VA, January 21, 2010).
[73] General James T. Conway, "Keynote Address" (Speech, USMC Expeditionary Power & Energy Symposium, New Orleans, LA, January 26, 2010). Cited hereafter as CMC Keynote Address.
[74] DSB, "More Fight", 24.
[75] Anthony Andrews, *Department of Defense Fuel Spending, Supply, Acquisition, and Policy*, CRS Report for Congress R40459 (Washington, DC: Congressional Research Service, September 22, 2009), 2.
[76] GAO Report, 7.
[77] McCarthy.
[78] Brookings Report, 2.
[79] DSB, "More Fight", Opening MEMORANDUM.
[80] DSB, "More Fight", 6.
[81] GAO Report, 31.
[82] GAO Report, 26-27.
[83] CMC Keynote Address.

[84] CMC, August 13, and Lucchino.
[85] MEAT Outbrief, October 1, 2009.
[86] Calculated from data contained in MEAT Outbrief, October 1, 2009. One fuel truck (M970) can carry 3,800 gallons of fuel in steep terrain. Source:http://en.wikipedia.org/wiki/M970, (accessed March 22, 2010).
[87] MEAT Outbrief, October 1, 2009.
[88] MEAT Outbrief, October 1, 2009.
[89] MEAT Outbrief, October 1, 2009.
[90] MEAT Outbrief, October 1, 2009, and Col Moore interview.
[91] GAO Report, 29.
[92] Col Moore interview.
[93] GAO Report, 29, and Col Moore interview.
[94] MEAT Outbrief, October 1, 2009.
[95] Headquarters U.S. Marine Corps, *Expeditionary Operations,* MCDP 3 (Washington, DC: Headquarters U.S. Marine Corps, April 16, 1998), 44.
[96]CMC, August 13.
[97] CMC, August 13.
[98] CMC, August 13.
[99] A can is a slang term for the 2-4 man mini-trailers that typically house Marines in FOBs.
[100] Brookings Report, 2.
[101] Col Thomas C. Moore, USMC, DARPA Liaison, "Marine Energy Assessment Team (MEAT): Afghanistan Assessment Outbrief" (Powerpoint Presentation for USMC Expeditionary Power & Energy Symposium, New Orleans, LA, January 26, 2010). Cited hereafter as MEAT Assessment, January 26, 2010, and Col Moore interview.
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[103] SgtMaj Carl R. Green, II MEF SgtMaj, "Behavior and Energy Use: Low Cost High Impact Strategies for the USMC" (Panel Discussion, USMC Expeditionary Power & Energy Symposium, New Orleans, LA, January 26, 2010).
[104] MCDP 3, 44.
[105] Griffith, 72.
[106] Using fuel burn rates contained in MEAT Outbrief reported convoy compositions (the details of which appear in Fully Burdened Costs Presentation.), for a round trip distance of 70 miles of road travel by the 18 vehicles accompanying each M970 fuel truck with 3500 gallons of fuel, the vehicles in the convoy burned 443 gallons of fuel.
[107] Calculated using same methodology as previous note.
[108] Col Moore interview.
[109] Deloitte Report, 1.
[110] Deloitte Report, 18, and Eric Schmitt, "Obama Issues Order for More Troops in Afghanistan," *NYTimes.com,* November 30, 2009.
http://www.nytimes.com/2009/12/01/world/asia/01orders.html (accessed March 10, 2010).
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[112] MEAT Outbrief, October 1, 2009..
[113] CMC Keynote Address.
[114] MCDP 3, 35.
[115] GAO Report, 22, 23.
[116] Brookings Report, 7.
[117] CMC Keynote Address.
[118] MEAT Outbrief, October 1, 2009.
[119] Tom Eggers, Director of Utilis USA, LLC, www.utilisusa.com, personal conversation with author, January 26, 2010, and "Efficient Shelters ExFOB Submittal Review," contractor comparison documents created by Marine Corps Warfighting Lab (MCWL) for Experimental FOB (ExFOB) evaluations, downloaded from USMC Expeditionary Energy Office (E2O) website (access granted by Col Charette, director USMC E2O) (accessed February 2010).

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[125] Park, and Shift CD.
[126] MEAT Assessment, January 26, 2010, and Col Moore interview.
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[129] Patrick J. Reynolds, Maj, USMC, email interview with author, March 22, 2010.
[130] The Centcom Sandbook is the "Construction and Base Camp Development in theU.S.CENTCOM Area of Responsibility (AOR). "The Sand Book" provides the U.S. Central Command's guidelines for FOB construction.
[131] "ExFOB EIPT Update Brief," March 4, 2010. Downloaded from USMC E2O Office website (access granted by Col Charette, director USMC E2O) (accessed March 10, 2010). Cited hereafter as ExFOB Update, March 4.
[132] ExFOB Update, March 4.
[133] "ExFOB EIPT Update 27 Jan 10," (Semi-private meeting attended by author, USMC Expeditionary Power & Energy Symposium, New Orleans, LA, 27 Jan 2010. BGen Robert F. Hedelund, Commanding General, MCWL in attendance). Cited hereafter as ExFOB Update, January 27.
[134] ExFOB Update March 4.
[135] Reynolds.
[136] ExFOB Update March 4.
[137] ExFOB Update, January 27.
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